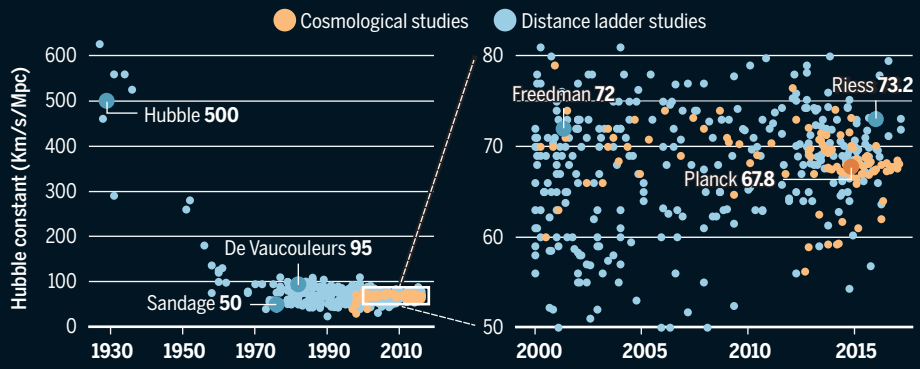
A COSMIC CONTROVERSY

By **Jia You**, **Chris Bickel**, *and* **Joshua Sokol**

Debate over the Hubble constant, the expansion rate of the universe, has exploded again. Astronomers had mostly settled on a number using a classical technique—the "distance ladder," or astronomical observations from the local universe on out. But these values conflict with cosmological estimates made from maps of the early universe and adjusted to the present day. The dispute suggests a missing ingredient may be fueling the growth of the universe.

***Data include known published Hubble constants. Cosmological studies rely at least in part on measurements of the cosmic microwave background.**

Not so constant



1929
Edwin Hubble's first value was much too fast. It implied a universe that was only 2 billion years old.

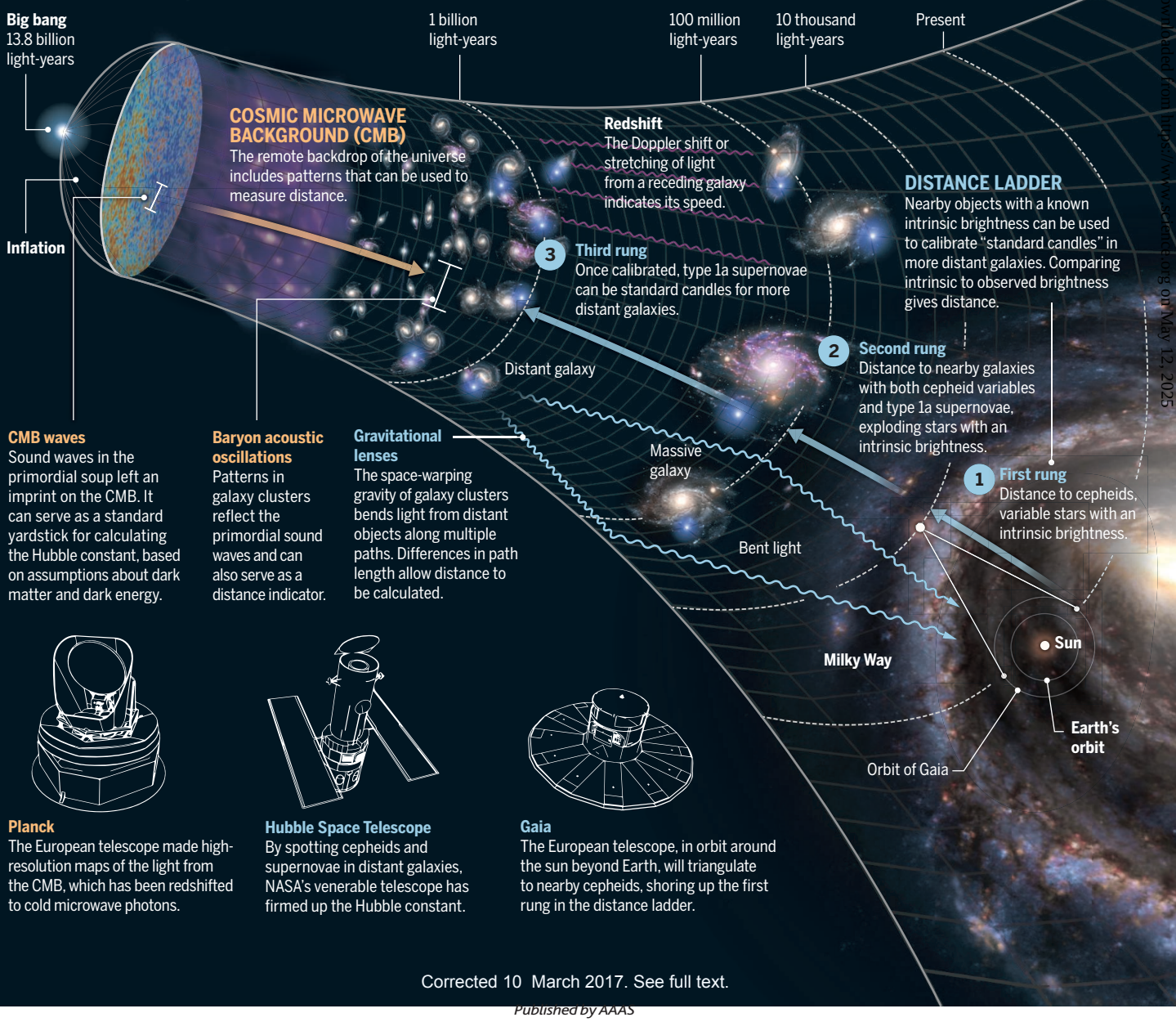
1976–1982
With the Palomar telescope, Allan Sandage found much slower rates, about half the value that his rival, Gérard de Vaucouleurs, was finding.

2001
In a prominent study, Wendy Freedman used the Hubble Space Telescope to settle on a constant of 72.

2015–Present
Debate has resumed. Adam Riess's distance ladder value is significantly higher than one derived from Planck's map of the cosmic microwave background.

Two ways to clock the cosmos

Determining the Hubble constant requires measuring the speed of receding objects and the distances to them. Speeds are easy, and come from redshifts. Distances are hard and rely on stars of known brightness or patterns of known size.



Planck
The European telescope made high-resolution maps of the light from the CMB, which has been redshifted to cold microwave photons.

Hubble Space Telescope
By spotting cepheids and supernovae in distant galaxies, NASA's venerable telescope has firmed up the Hubble constant.

Gaia
The European telescope, in orbit around the sun beyond Earth, will triangulate to nearby cepheids, shoring up the first rung in the distance ladder.

Corrected 10 March 2017. See full text.

Published by AAAS